Allocating Commodities in Inflation Hedging Portfolios: A Core Driven Global Macro Strategy

Fulli-Lemaire, Nicolas

University of Paris 2, Amundi AM

26 March 2012

Allocating Commodities in Inflation Hedging Portfolios: A Core Driven Global Macro Strategy

Nicolas Fulli-Lemaire[1]

Amundi Asset Management
Paris II University

Second Version: 15/10/2012

Abstract

Recent academic studies have shown that since the mid-nineties, the pass-through of exogenous oil shocks into headline inflation has been increasing while the pass through into core inflation seems to have ceased. This paper explores the implications in terms of commodity allocation for inflation hedging portfolios these recent works have paved the way for. We proceed by first evidencing a link between the headline to core inflation spread and tradable commodities. We subsequently intend to exploit this link in three ways: Firstly by devising an efficient strategic allocation using core inflation forecasts to determine the commodities' natural weight in the portfolio as dictated by our macro approach. Secondly by testing a tactical allocation strategy which would time the pass-through cycle to dynamically determine the optimal share of commodities in the allocation. And finally by proposing a strategy to arbitrage core inflation-linked derivatives by cross-replicating them with commodity portfolios.

Keywords: Inflation Hedging, Portfolio Allocation, Commodities, Core Inflation, Global Macro, Inflation Pass-through, Arbitrage Pricing, Strategic Allocation, Tactical Allocation

JEL classification: C58, C63, E3, G11, Q02, N1

[1] This document presents the ideas and views of the author only and does not reflect Amundi AM's opinion in any way. It does not constitute investment advice and is for information purpose only.

Plan

Introduction

The intricate relationship between crude oil prices and macroeconomic variables, inflation in particular, has been extensively studied in the last decade. Following the seminal work of (Blanchard & Gali, 2007), it has been commonly accepted that the pass-through of exogenous oil price shocks to output and inflation has greatly diminished since the nineties, thereby severely reducing their role as drivers of long-term inflation and economic crisis. Moreover, (Todd & Stephen, 2010) and (van den Noord & André, 2007) have shown that the transmission of oil price shocks into core inflation has now basically ceased, thereby greatly differentiating the behavior of core and headline inflation. Yet, to the best of our knowledge, no research paper has focused precisely on the implications in terms of commodity allocation for inflation hedging portfolio management that this macroeconomic shift implies.

The question of the optimal allocation of commodities in an inflation hedging portfolio has been central to academic research since the end of the era of cheap oil in the seventies in the United States. The first article directly addressing this issue was (Bodie & Rosansky, 1980) which advocates the inclusion of commodities as natural inflation hedges. Commodities can be included in a standard portfolio optimization framework for two main reasons: firstly, commodities have offered potentially strong nominal returns and are a source of performance enhancement on a risk-adjusted basis as they are potentially decorrelated from other standard asset classes. Secondly, commodities seem to offer interesting inflation hedging properties. Yet, commodities are cyclical and can suffer from very sharp downturns, of magnitudes that greatly dwarf inflation variations, thus rendering their inclusion into inflation hedging portfolios non-trivial.

The mainstream of academic literature over recent decades has been made up of response function analysis following the seminal work of (Campbell & Viceira, 2002) which introduced the use of structural Vector Autoregressive Models (VAR) allowing the computation of response functions to inflationary shocks, regime change or more complex scenarios in the case of Markov Switching models. It has recently expanded into the co-integration universe with the use of Vector Error Correction Models (Amenc, Martellini, & Ziemann, 2009). Though such works may offer some interesting insights, their statistical justification is quite weak and their out of sample efficiency remains to be proved. In fact, such models do not try to exploit the relationship between commodity price shocks and inflation but rather tend to measure the potential unexpected-inflation hedging resilience of an asset class, were such an event to occur.

Since no publicly available, global macro approach using pass-through literature to allocate commodities has been proposed, we investigate this issue in this article: we will attempt to define a natural commodity allocation derived from their expected contribution to headline inflation trends using forward core values as an allocation metric. The first section of the article will be dedicated to a review of the literature concerning changes in the pass-through, its measurement and commodity allocation research. The second section will investigate the impacts of this shift into financial securities' pricing and correlation structure,

then propose strategies aimed at exploiting them. Finally, the last section will evaluate three possible exploitations of our findings: a strategic allocation framework, a tactical allocation framework and a commodities and fixed income derivative arbitrage.

1. Shifting paradigm, vanishing pass-through and allocation issues

1.1. *The macroeconomic literature of the shifting paradigm*

One of the great macroeconomic paradigms of the twentieth century was that exogenous oil shocks were harbingers of macroeconomic chaos in the form of surging inflation, restrictive monetary policies and severe drop in output. Collective memories of the two major oil shocks in the seventies largely fed into this. However, a recent stream of literature has challenged this assumption on the basis of new evidence pointing at a much reduced role for oil price shocks in terms of being a generator of macroeconomic volatility. The seminal article of (Blanchard & Gali, 2007) completes this literature by trying to measure and explain the diminishing macroeconomic impact of oil shocks since the eighties as compared to the seventies. Using *a structural vector autoregressive* (SVAR) model, they estimate *impulse response functions* (IRF) to exogenous oil price shocks. Their rolling timeframe estimation results point at a clear reduction in the impact of shocks since the mid-eighties. In a later paper, (Blanchard & Riggi, 2009) estimated a simpler new-Keynesian model derived from these observations aiming at explaining the causes of the shift. The authors evaluate and model three possible explanations found in the literature: a reduction in the energy intensity of output, a relaxation of the real wage rigidity or the effectiveness of new central bank monetary policies. These hypotheses can in turn be explained by their respective literature:

The decline in energy intensity of US output measured by (Wing, 2008) could be the result of both intra-industries energy efficiency improvement and inter-industries sectorial reorientation of productive capacities toward less energy intensive ones such as services.

The vanishing real wage rigidity is documented in (Card & Hyslop, 1997) which showed that between the seventies and the eighties, an increasing number of employees were not receiving inflation neutralizing raises, therefore upholding the belief that inflation "greases the wheels of the labor market" by eroding in time the downward nominal wage rigidity.

The increased effectiveness of central bank monetary policies has been largely attributed to the successes of inflation targeting monetary policies introduced in the early nineties. By also using an SVAR to calibrate a general equilibrium model, (Boivin & Giannoni, 2006) have shown that compared to the eighties, monetary policy exogenous shocks seem to have a much lesser impact in term of volatility of inflation and output. Also, the reduced size and increased frequency of monetary shocks seem to point at a more proactive and efficient policy response. All of these elements tend to demonstrate an enhanced credibility of central banks at achieving price stability.

The most interesting aspect of this macro-shift for our purpose can be found in the first of Blanchard's papers cited (Blanchard & Riggi, 2009). The authors note that by comparing the results obtained over the twenty years or so before and after 1980, the contribution of oil shocks to economic fluctuations remained flat for GDP and employment, declined by half for wage inflation and the GDP deflator while it increased by almost a half for CPI inflation. But most importantly, these observations are consistent with the core CPI remaining stable as oil

price shocks are passed on to the energy component of the CPI and, according to their estimate, account for up to sixty percent of its volatility. This brings us to our second point: the vanishing pass-through of energy price shocks from headline to core prices.

1.2. *The vanishing pass-through*

Exogenous oil shocks are, by conventional wisdom, the main drivers of CPI inflation: this passage of changes in the prices of energy to the general price level in the economy as measured by the CPI has been dubbed the *inflation pass-through of energy prices*. While it was indisputably fairly large until the late seventies, it is then quite amusing as (Hooker, 1999) noted that the very nature of this close relationship broke down at the very moment when (Hamilton, 1983) published its landmark paper on the link between oil prices and macroeconomic variables.

There is an extensive body of literature that delves into this vanishing pass-through and provides a variety of possible explanations and ways to measure it: (De Gregorio, Landerretche, & Neilson, 2007) extend the (Blanchard & Gali, 2007) paper by incorporating a much larger set of 34 countries, including emerging ones and estimate the pass-through using IRFs derived from an SVAR analysis and an enhanced Philips curve with oil parameters. They conclude that it has fallen significantly since the mid-seventies for all developed countries and, to a smaller extent, in emerging markets. This reduction has been the result of both a decline in the economic intensity of oil use and the impact of favorable exchange rates as the latest oil shock has been demand-driven (therefore resulting in an appreciation of exporting countries' currencies). Both of these new arguments still fail to explain a significant part of the reduction of the pass-through as the authors conclude. Using an equivalent methodology, (Chen, 2009) points out the degree of trade openness as the only statistically significant additional explanatory variable included in his analysis, but still fails to explain a large part of the pass-through decline.

The other interesting aspect of this pass-through is the transmission of energy price variations from headline to core inflation. The oil-inflation paradigm previously exposed would have those variations reflected immediately in headline CPI and then progressively transferred into core CPI measures as economic agents gradually adapt their prices to a change in energy input prices. This transmission mechanism would end-up closing the gap between both indicators. In essence, it would be a headline to core inflation pass-through. In fact, core CPI measures are often disregarded by financial professionals as merely lagged estimates of headline CPI. But as all paradigms seem doomed to fail, (van den Noord & André, 2007) showed that during the recent crisis, core inflation's reaction to headline spikes remained totally muted in both the US and Europe. Once again, the reduction in energy intensity is identified as the main explanation of this, but so is the fact that this recent crisis occurred at a time of economic slack compared to previous ones in the seventies in particular. (Todd & Stephen, 2010) went down this path using a more complex time-varying-parameters and stochastic-volatility-Bayesian-VAR methodology to precisely estimate the pass-through

of energy prices variations to core inflation in the US. They estimate that since approximately 1975, core CPI in the US had gradually become less responsive to changes in energy prices. By 1985, the pass-through had been reduced to nil.

1.3. *The case for a commodities allocation in asset liability management*

Commodities have been exchanged in spot and futures format since immemorial times and were most certainly the subject of the first derivative trades. Yet, they have only recently attracted the attention of portfolio managers as a strategic investment class. In fact, the first meaningful articles on the issue of incorporating commodities into an investment portfolio are contemporaneous with the first major oil shocks since the Second World War and the surging inflation that accompanied them. Back then, they had already been studied in conjunction with inflation: in the early eighties, (Greer, 1978), (Bodie & Rosansky, 1980) and (Bodie Z. , 1983) explore their inflation hedging potential. Since then, the number of articles exploring the potential of commodities as an alternative asset class both for performance enhancement and liability management is simply astonishing. The impressively long bull-run of commodities in the previous decade certainly helped as contrarian showed (Daskalaki & Skiadopoulos, 2011) in their out of sample analysis.

The benefits of a commodity allocation are usually described as investing in an asset class with equity-like returns and low correlation with traditional equity-bond-cash portfolios (Conover M. C., Jensen, Johnson, & Mercer, 2010). The question of the correlation of this specific asset class to other more conventional ones has been studied in depth by (Chong & Miffre, 2010). However, it is regrettable that linkers were excluded from this analysis even though there is an obvious historical depth availability issue. More specifically, the potential of commodities to hedge against unexpected inflation has been explored in (Attié & Roache, 2009) even though (Erb & Harvey, 2006) note that a specific distinction should be made between commodities as a whole and commodity indices which experience a fairly different kind of return and correlation profile. After the energy component, the second most studied commodity sub-index has been precious metals which also exhibit interesting inflation hedging potential in times of severe downturn and "flight to safety" phenomenon (Conover C. M., Jensen, Johnson, & Mercer, 2009). Lastly, the tactical value of commodities in a general portfolio optimization framework was shown in (Fuertes, Miffre, & Rallis, 2010) to name just one of the many articles on this subject.

The inflation hedging potential of commodities has fueled research into their inclusion in liability driven investment strategies. (Hoevenaars, Molenaarb, Schotman, & Steenkamp, 2008) justify their inclusion in a simulated Asset Liability Management (ALM) analysis for both their risk diversification benefits and their inflation hedging capacities. The same is true for the long only investment approach of (Amenc, Martellini, & Ziemann, 2009) and (Brière & Signori, 2010). However, all these papers ignore the macro aspect of the allocation. This type of approach combining a liability (a.k.a. an inflation risk) and a macroeconomic tactical

allocation can be found for example in the long-short macro-timing of the commodity allocation of (Jensen, Johnson, & Mercer, 2002).

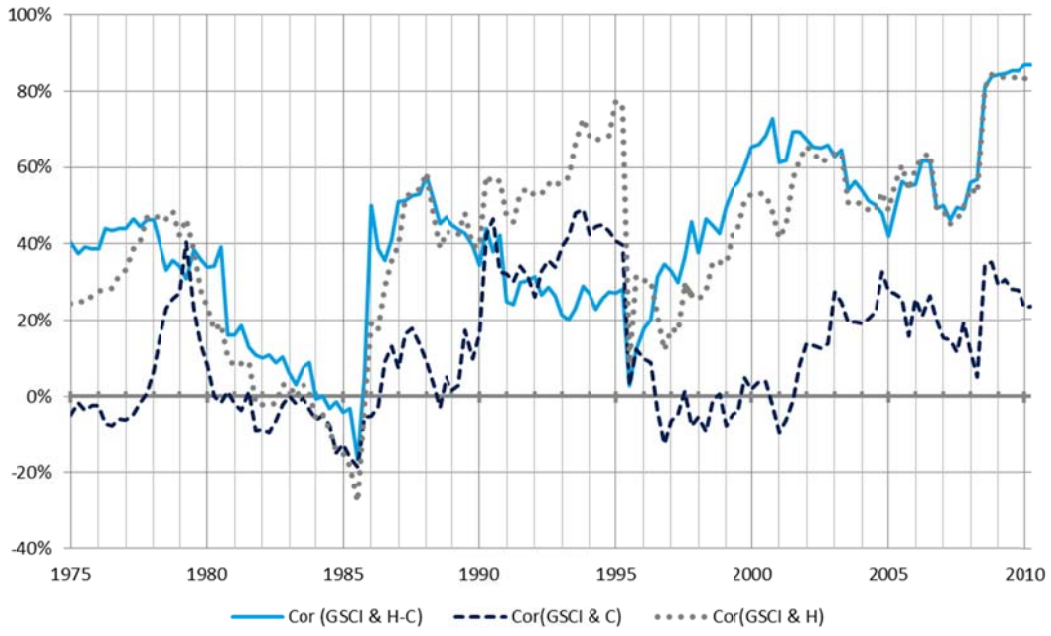
To the best of our knowledge, no research has focused specifically on the allocation implications of the commodities-to-inflation pass-through previously exposed in terms of inflation protected portfolios. Yet, if we are to believe (Brière & Signori, 2010) and (Attié & Roache, 2009), commodities do offer a relatively good inflation hedge up to a certain horizon, after which their hedging potential seems to gradually wane. Could this be a result of the pass-through of commodity price inflation to core prices? Considering for example the previously mentioned academic research into the pass-through, could we envisage looking at the core versus headline inflation cycles as an indicator for the timing of the allocation?

2. Financial asset consequences of the shifting macro-structure

2.1. *Historic correlations analysis*

A first impression of the impact of the pass-through in terms of asset prices can be assessed by calculating the correlation between a commodity index on the one hand and headline inflation, core inflation and the difference between the two on the other hand.

Figure 1: Rolling time frame correlation analysis between commodities and inflation indices



We plotted in Figure 1 those three measures for quarterly data over the 1975-2010 period using a 20-quarter rolling time frame and using the GSCI-TR (*the Goldman Sachs Total Return Commodity Index*). From this first rough insight, we can grasp that the correlation

between the commodity index and core inflation (*dark blue dashed line*) is on average quite low and unstable through time. The correlation between headline inflation and the commodity index (*grey pointed line*) is also unstable but secularly increasing over times, even though it is subject to brutal regime changes in terms of correlation levels. We can speculate that they appear to be synchronous with severe macro or oil specific events (or both) such as the 1985-86 counter oil shock (Mabro, 1987) or the US 1992 recession (Hamilton, 2011). The correlation between the commodity index and the volatile fraction of the inflation index a.k.a. the headline vs. core spread (*solid light blue line*) has more or less been continuously rising since the mid-eighties and has risen above 80% in recent years. Its trend has been so closely linked to its headline counterpart that it has even gone up to the point of being indistinguishable from it in the last ten years.

Consistently with prior literature, our computation exhibits a new correlation regime that began in the nineties: core inflation appears weakly correlated with commodities but is somewhat upward trending. Headline inflation's correlation with commodities appears very strong and its evolution has been matched by the correlation between the inflation spread and commodities. But how will it evolve going forward? Is it a transient state as a result of the current market turmoil or is it a stable long term-trend? The last subsections will delve into this issue with a co-integration analysis to try to answer this point. The previously exposed literature gave an economic explanation for the link between spot oil prices and headline inflation or for the absence of it when it comes to core inflation and our simple correlation analysis does seem to support an investment strategy. We will therefore explore the possibilities in terms of inflation hedging strategies that this new framework enables in the next subsection.

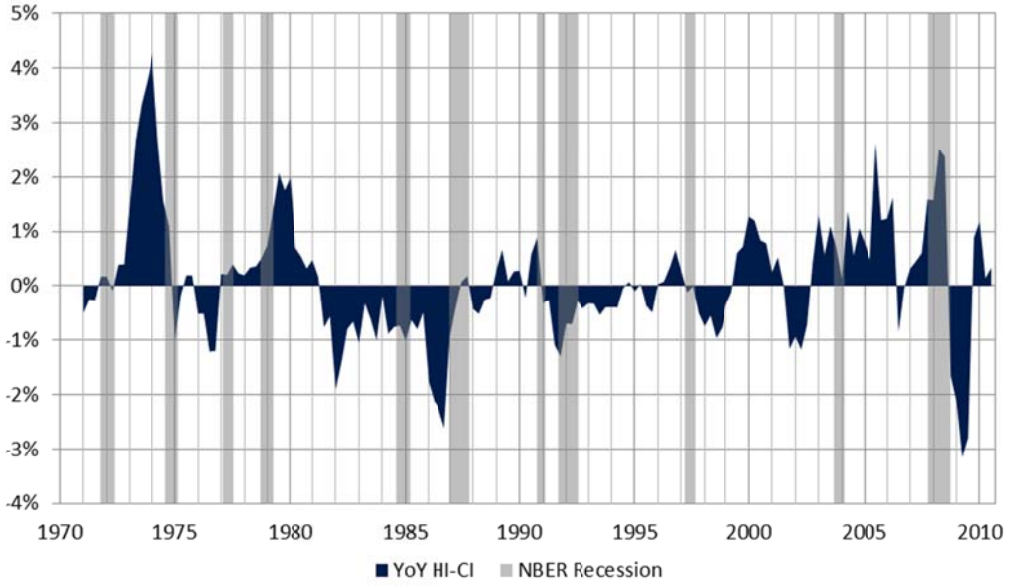
2.2. *Pricing implications of the pass-through*

The estimated level of the pass-through should drive our strategy in the following way: should an exogenous energy price shock hit the economy, headline inflation (HI) would spike contemporaneously with the commodities index while core inflation (CI) would remain stable. The difference between the returns of the CI and HI index should initially also be highly correlated with the commodity index, while the correlation of the CI to the same index should be low. Then, after a certain lag, two scenarios are possible:

Either the pass-through does operate and the general price level in the economy adapts, therefore diminishing the hedging potential of commodities as the CI catches up with core HI and eventually overshoots it. If this scenario were true, then the evolution between CI and HI (both in level and in correlation to commodities) should be an indicator of the allocation: during the first part of the cycle we should be relatively long on commodities, while we should gradually short the position towards the end of the cycle. The commodities in the allocation should gradually be substituted for other kinds of asset which would be more prone to hedge the CI as it becomes dominant towards the end of the cycle.

Or the pass-through doesn't operate and the CI response to the spiking of commodities remains muted. If this were the case, CI would remain – ceteris paribus – flat while the HI should eventually mean revert towards CI. If this alternative scenario were true, then the joint evolution between CI and HI (both in level and in correlation to commodities) would also be a different indicator for the allocation: the CI-HI correlation should remain high throughout the cycle. If our objective is primarily an inflation hedge, then we should calibrate a strategic commodity allocation to correspond to the forecasted residual spread between CI and HI.

Figure 2: Year on year headline minus core inflation over forty years

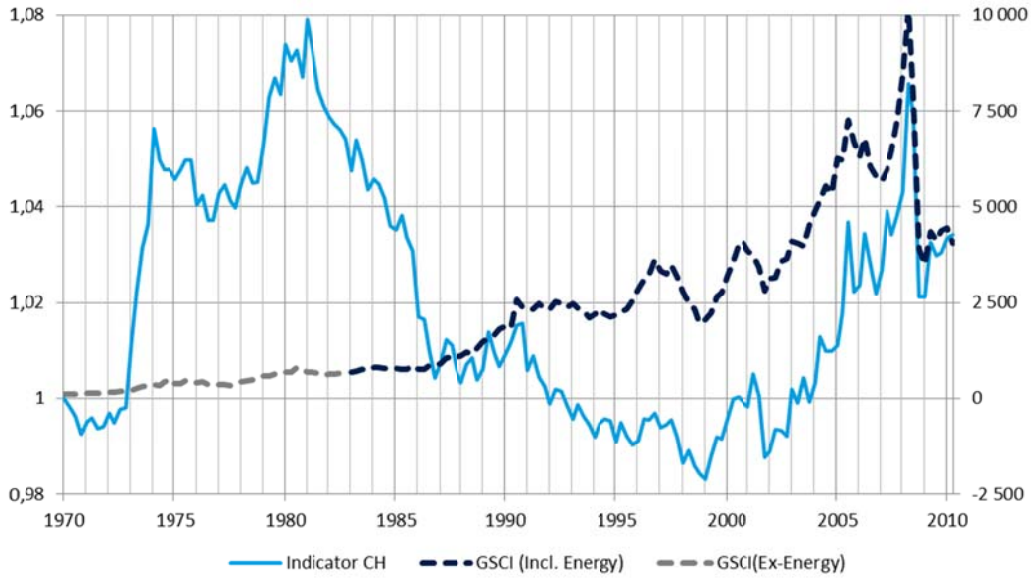


Therefore, if the pass-through does operate, we should have a *tactical allocation indicator* whereas if it doesn't, we should have a *strategic allocation indicator*. We shall evaluate those two options in the next section. In accordance with our prior hypothesis, we compute the tactical indicator as the integrated difference between the returns on CI and HI (*light blue continuous line*). We obtain Figure 2 by superimposing with a different axis the contemporaneous evolution of the GSCI_TR index (*dark blue dashed line*). We also separately represented the GSCI_TR prior to the inclusion of energy commodities in December 1982 (*light grey dashed line*) when their liquidity was deemed sufficient.

As could be expected from the correlation analysis, there seems to be no clear relation between those two time series up until the late nineties, when there are clear hints of comovements, if not an outright cointegration relationship. In fact, considering the methodology employed by the statistical body on the one hand, and the computation of the commodity index, it is not initially obvious that such a relationship could hold. We are de facto comparing a consumer price derived index to a financial market derivative transaction based index, both of which could easily answer to very different drivers: the GSCI_TR could

be very sensitive to market manipulation or short-term adjustments, whereas the other index could be subject to seasonal effects (we chose not to use a seasonally adjusted indicator).

Figure 3: A Comparison of the GSCI TR index and the integrated difference of CI and HI



This kind of argument could also offer a tentative alternative explanation for the weak relationship early on in the period: at this moment in time, commodities financial markets were much less developed, more illiquid and trading costs were extremely high. Such events would put a serious drag on the returns of the GSCI_TR during much of the seventies and eighties whereas the consumer price index did not suffer from such disadvantages.

2.3. *Cointegration analysis as a predictor of long-term trends*

As any investor knows or should know, "*past performance is no guarantee of future results*". The main caveat of our study lies in the fact we have until now tried to justify with fundamental macroeconomic arguments the existence and the evolution of the correlation structure we have exposed previously but we have not provided any indisputable proof that would ensure the persistence of the correlation through time. And there is clearly none. Still, we could partially reinforce our econometric assumptions by running a cointegration test to evaluate the potential for shifts in the current structure or its probable persistence which a strong cointegration relation would favor.

Using the cointegration framework developed by (Granger & Newbold, 1974), we explore the possibility of a spurious regression by testing for cointegration using the (Johansen, 1988) test after having performed an integration test using (Said & Dickey, 1984). Since there are multiple possible structural breakpoints in the correlation structure, we will

perform the test using several timeframes as before. Firstly by testing over the entire sample, then on several sub-samples which represent our areas of interest. The choice of those breakpoints is derived from the pass-through literature, not an endogenous selection like (Andrews, 1993).

Table 1: ADF tests for unit root

Variable:		Indicator_CH		GSCI_TR	
Range	**Test option**	**ADF t-statistic**	**AR(1) estimate**	**ADF t-statistic**	**AR(1) estimate**
1970-2010	No deterministic part	0.013 ***	1.000	-0.120 ***	0.998
	Constant plus time-trend	-2.064 ***	0.945	-2.953 ***	0.839
1970-1995	No deterministic part	-0.549 ***	1.000	0.741 ***	1.012
	Constant plus time-trend	-2.435 ***	0.916	-2.056 ***	0.899
1995-2010	No deterministic part	0.917 ***	1.001	-0.235 ***	0.993
	Constant plus time-trend	-2.420 ***	0.562	-2.554 ***	0.382
2000-2010	No deterministic part	0.353 ***	1.001	-0.667 ***	0.966
	Constant plus time-trend	-1.244 ***	0.157	-0.778 ***	0.446

Note : */**/*** denotes the significance at the 10%/5%/1% level

In order to check for long-term trends which would uphold the case for long-term stability, we check the validity of a cointegration hypothesis using a Johansen test. We first check for evidence of integration in our time series using the Augmented Dickey-Fuller (ADF) test with constant and time trend whose results are exhibited in Table 1. The first and most unsurprising conclusion we have is that can we reject the null hypothesis (I(0)) for both our time series and at any period in time. Our result is statistically significant at the 1% level. The second conclusion we can reach is that the process driving our two time series is almost perfectly integrated of order 1 since we obtain AR(1) parameter estimates insignificantly different from 1 in the case of the estimations with neither constants nor time-trends. If we include those parameters, as could have been expected, we obtain parameter estimates significantly different from 1, especially in the more recent estimates.

We can therefore perform the regression analysis and test for spurious regressions using the Johansen Test as is presented in Table 2.As expected, the regression analysis yields a low Adjusted R^2 for the overall period studied and for the 1970-1995 period. However, it gives a higher Adjusted R^2 for the 1995-2010 and the 2000-2010 period. The last of the two periods' R^2 is slightly smaller (contrary to our correlation analysis) partly because of the adjustment of

the R^2 to the sample size (which is smaller in the second case). All the regressions are significant to the 99% threshold except for the first one over the entire 1970-2010 period.

Table 2: Long-run equilibrium and cointegration test results

Dependent Variable:		**Core Headline Inflation Indicator**			
Range:		1970-2010	1970-1995	1995-2010	2000-2010
#Observations:		163	100	63	43
Independent Variables					
Constant		1.024	1.041	0.967	0.971
		(0.003)	(0.004)	(0.003)	(0.006)
GSCI_TR	(x10^6)	-1.907	-14.764	9.784	9.224
	(x10^6)	(0.956)	(3.069)	(0.740)	(1.116)
Adj. R^2		2.41%	19.10%	73.83%	61.91%
Fisher		3.981 ++	23.136 +++	174.875 +++	68.267 +++
p-value		0.048	5.5E-06	1.1E-19	2.4E-10
Note : +/++/+++ denotes the significance at the 90%/95%/99% level					

Johansen Test for constant plus time-trend:

Statistic	**Null**				
Trace	**r< = 0**	20.702 **	8.863	10.494	10.908
	r< = 1	2.645	3.460 *	3.458 *	5.218 **
Eigen	**r< = 0**	18.057 **	5.403	7.035	5.690
	r< = 1	2.645	3.460 *	3.458 *	5.218 **

Note : */**/*** denotes the significance at the 90%/95%/99% level using critical values generated using MacKinnon (1994, 1996)

As we expected, the cointegration hypothesis is upheld according to our Johansen Test for the 2000-2010 period and weakly rejected for the other sample periods. More precisely, we can reject the cointegration hypothesis for the 1970-2010 period at the 95% level, and we upheld the hypothesis for the 2000-2010 period at the same level. For both the 1970-1995 and 1995-2010 period, we have weak evidences of cointegration (significant only at the 90% level). We can therefore conclude that according to our study, the cointegration seems to have begun in the early 2000 and is still holding today. It is consistent with literature on the macroeconomic model. We should therefore expect our strategic allocation strategy to perform better in a historic backtest for the 2000-2010 timeframe and less so before that. Inversely, we should expect our tactical allocation to outperform in the preceding period and underperform in the more recent period.

3. Empirical estimations of allocation and arbitrage applications

3.1. *Strategically allocating commodities in inflation hedging portfolios*

Building on the previously mentioned macroeconomic literature on the absence of pass-through into core inflation of commodity price shocks and its asset pricing implication in terms of asset correlations we briefly explored in the previous section, we aim to formalize the following strategic allocation for commodities:

We have shown that the spread between HI and CI is highly correlated to commodities whereas their correlation to core inflation is negligible. The allocation of commodities in our inflation hedged portfolio should accordingly be targeted at hedging this fraction of the inflation risk. We therefore built a two fund portfolio with a first allocation intended to hedge core inflation, while the second one is aimed at hedging the residual inflation spread. If commodities proved to be a natural investment to hedge the inflation spread, finding a core inflation hedging asset will be more arduous for two reasons: firstly, there is no asset as of today with cash flows linked to core inflation and secondly, core inflation is an economic concept which is very poorly correlated to any tradable security. However, since core inflation displays very low volatility on short to medium horizons, we could envisage a partially unhedged strategy in which we would remain at risk on the core inflation part as forecasts should not be too far off the ex-post realized value because of the low volatility.

We then define the following long-only strategy in which we secure with a nominal bond investment the expected core-inflated value of our investment while remaining at risk on unexpected core inflation –defined as the difference between ex-post realized and ex-ante forecast– and playing the natural cross-hedging of commodities with the inflation spread to hedge it. We should therefore achieve an extreme event hedging of headline inflation while benefiting from the real rate premium derived from the nominal bond investment.

To perform the backtesting of our proposed strategic allocation we used fixed-income and commodity data obtained from Bloomberg. Inflation data were retrieved from the FRED database. We use forecasted core inflation data either obtained from the survey of professional forecasters when it is available or computed using a very conservative hypothesis of stability in level and a term-structure shaped by the headline forward curve when it is not. We use only information available at the time of the investment to avoid "back-trading" or data mining biases. This dataset is available only from 1990 onward, thus constraining us.

The zero coupon bond whose maturity matches our target investment one is allocated such that it terminal value equals the expected core-inflated value of our investment fraction of the portfolio. Let CI be the forecasted core inflation and $\tau_{0,t}^{ZCN}$ be the zero coupon nominal rate, we can therefore write the fixed income allocation as:

$$FI_{0,t} = \left(\frac{1 + CI_{0,t}}{1 + \tau_{0,t}^{ZCN}}\right)^{t}$$

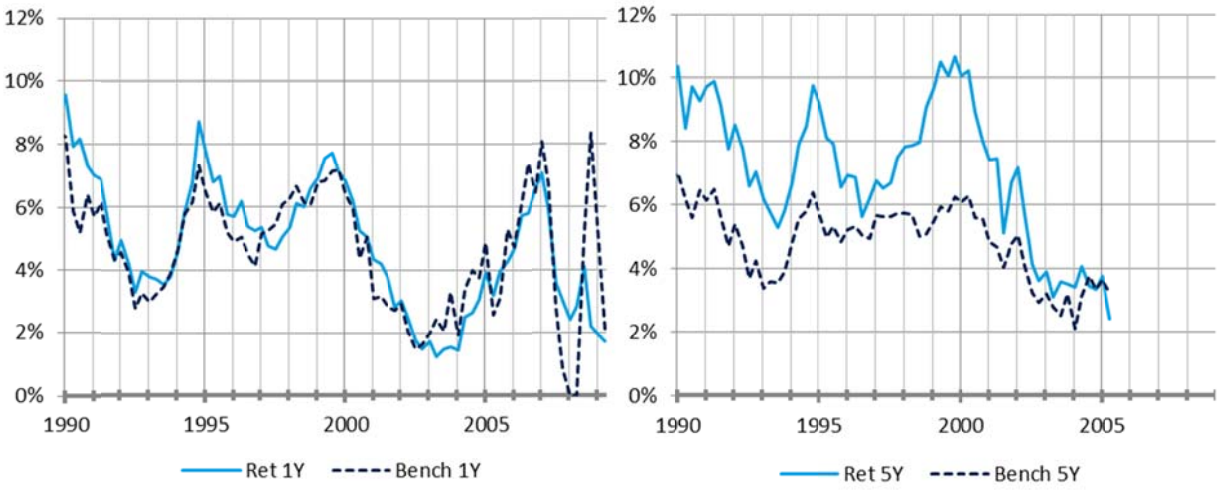
The residual part of our investment is allocated in commodities and we will assume its performance is equal to that of the GSCI_TR total return index.

Table 3: A commodity enhanced bond portfolio vs. a linker benchmark:

Maturity	1Y		2Y		3Y		4Y		5Y	
Portfolio	Alt.	Bench.	Alt.	Bench.	Alt.	Bench.	Alt.	Bench.	Alt.	Bench.
1990-2010										
Average	5.18%	4.87%	5.51%	5.26%	5.98%	4.43%	6.59%	5.44%	7.18%	4.94%
Std.	2.20%	2.10%	4.31%	3.34%	5.89%	2.92%	7.72%	5.69%	11.24%	6.13%
IR	0.140		0.291		1.394		1.307		1.769	
2000-2010										
Average	3.66%	3.88%	4.05%	4.19%	4.60%	3.80%	5.04%	4.39%	5.64%	4.10%
Std.	1.77%	2.16%	2.98%	2.96%	4.81%	2.08%	8.60%	5.08%	13.00%	6.25%
IR	-0.145		-0.180		0.763		0.615		1.059	

We will define the benchmark against which we will test our strategy as a pure investment in linkers with a maturity matching that of the investment horizon. The return of the benchmark is therefore equal to the real rate defined at inception plus the accrued headline inflation over the life of the linker and floored at zero to respect TIPS characteristics. Real rates are defined as the difference between the US nominal zero coupon sovereign rate and the breakeven inflation of matching duration. The performance of the strategy compared to its benchmark is presented in Table 3.

Figure 4: Out of sample evaluation of the strategic allocation vs. a benchmark portfolio.



The performances for two target maturities are represented as an illustration in Figure 4.

For maturities above three years, our alternative strategy consistently beats its benchmark in terms of Information Ratio (IR) and mean absolute return for both time periods studied here, albeit with higher volatility. The strategy's performance is increasing through time except at the four year horizon, though the difference with the three year is clearly not statistically significant. Contrary to our pass-through hypothesis, the strategy does perform better during the 1990-2010 period than in the 2000-2010 period. It is probably explained by the severe counter-performance of nominal bonds contemporaneous with spiking inflation during the 2008-2009 US financial crisis as a result of flight to quality. The same is probably true for the one and two year horizon investment underperformance with respect to the benchmark in the 2000-2010 period as a result of severely depressed nominal rates. Real rates even went negative at times during the height of the crisis.

Our strategic allocation for commodities derived from the pass-through hypothesis seems to be supported by this backtesting exercise though we must point out several important caveats: firstly, commodities have enjoyed an exceptional bull-run through much of the period studied and it certainly biased upward the returns of our strategy by generating abnormal real returns. Secondly, the heredity of the *Great Moderation* has resulted in decreasing inflation and inflation risk premium throughout the period studied, therefore making realized unexpected inflation negative on average, thus also boosting our strategy's performance. And thirdly, the absence of available data prior to 1990 impedes the computation of the strategy's performance during a period of higher pass-through which would have been interesting for comparison purposes.

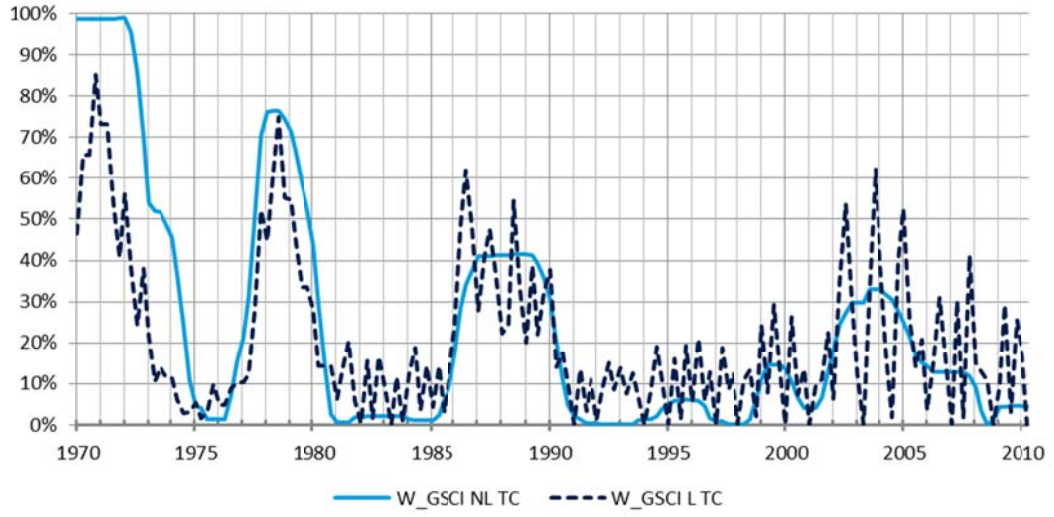
3.2. *Tactically allocating commodities in inflation hedging portfolios*

The second potential application for the pass-through literature in term of portfolio management we would like to explore in this article is the market-timing power of the pass-through indicator: considering our asset pricing hypothesis relative to the pass-through cycle, we could envisage to use its estimation in order to time the cycle by going long on commodities when the gap between HI and CI widens (increase in the inflation spread) and reduce our exposure to commodities when the gap closes as either the pass-through operates or simply HI is falling as it mean revers towards CI. We will be using low frequency data as there is too much noise below the quarterly frequency to monitor such a slowly evolving macroeconomic variable. The particularity of this tactical allocation approach is that we will try to time commodities' contribution to inflation regardless of any maximization of their potential nominal or real return.

The first assessments of our strategy that we will be conducting consist in an ex-post comparison of the optimal commodity allocation in a commodity and cash portfolio versus the pass-through indicator. We construct a quarterly rebalanced portfolio made up of both GSCI_TR and theoretically risk-free US sovereign three month T-Bills which optimal ex-post commodity allocation is performed by maximization of the portfolio's Sharpe ratio. The obvious pitfall of this methodology is that we clearly do not want to be running a "back-

trading" exercise but rather capture only low frequency "fundamental" movements as opposed to high frequency market timing moves. To achieve this goal, we run the optimization using trading cost which penalizes too frequent "opportunistic market-timing trades" while favoring long time trend reallocations. Since those results would still be too volatile to capture the phenomena we target, we used both proportional trading cost and nonlinear trading costs (which evolve with the square of the trade size) following (Amihud & Mendelson, 1986) and (Vayanos, 1998). This adjunction enables to obtain a credible allocation in terms of asset turnover with a reasonably high trading cost of up to 5% of turned-over assets (which is still considerably higher than what current trading costs are on average). The smoothed (nonlinear) allocation curve obtained (*light blue continuous line)* is plotted along with the linear trading costs curve (*dark blue dashed line*) in Figure 5.

Figure 5: Optimal ex-post commodity allocation using proportional and nonlinear frictions

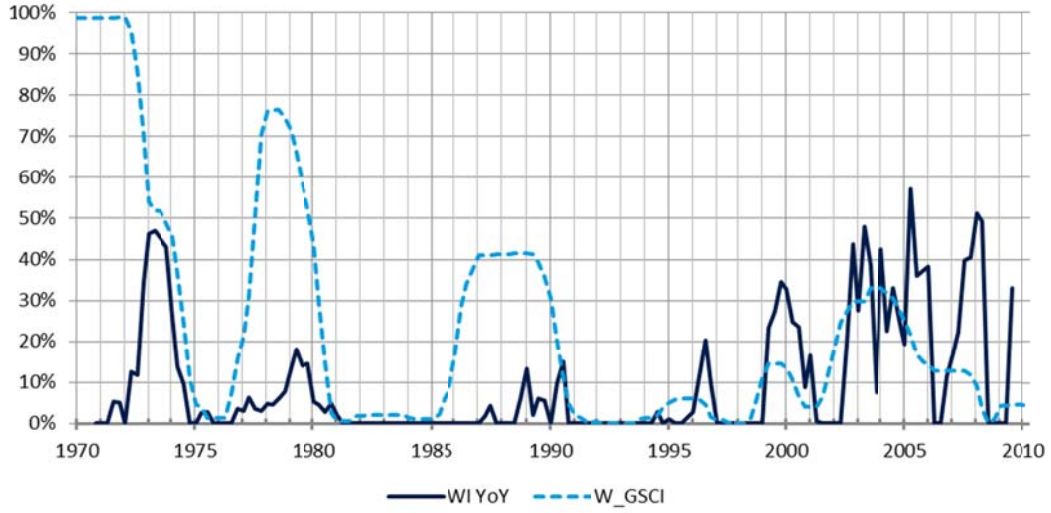


Since our working hypothesis would suggest that the difference between the rate of the CI and HI inflation is related to the optimal commodity allocation, we built the following allocation indicator (WI) as follows: the WI equals the yearly average of the ratio of the difference of the HI and the CI (if positive and 0 otherwise) over the HI if positive (0 otherwise). We then take the min of WI and 1 and the max of the previous condition and 0. The result is presented in Figure 6 (*continuous dark blue line*).

Comparing our optimal ex-post commodity allocation with the WI indicators we built yields the following observations: the three clear episodes of high allocation or commodities in our simulated portfolio in the early seventies, late seventies and eighties ended contemporaneously with a peaking followed by a sharp decrease of our indicator. It is slightly less clear but still apparent for the three latter episodes of higher commodity allocation in the 1990-2002 period. It then becomes completely uncorrelated in the 2002-2010 period during which our indicators becomes much more volatile and thus becomes less useful from an allocation point of view as its exploitable signal seems drowned with noise. These

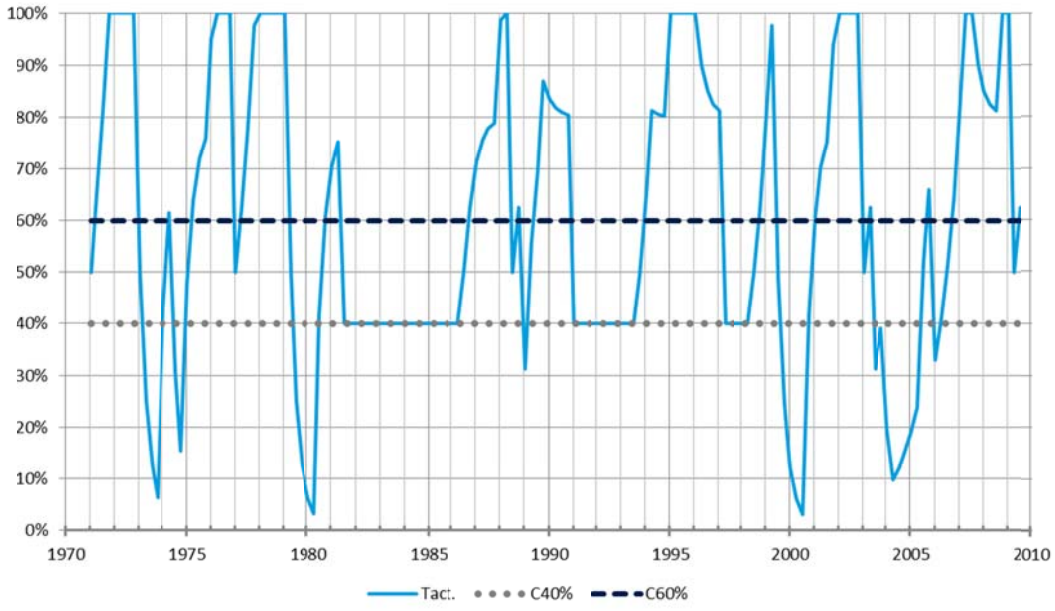
observations are consistent with our tactical allocation hypothesis which stated that the indicator should be more efficient at times when the pass-through does operate. Since the econometric literature we previously exposed dates this cessation to the early nineties, it is therefore logical that the WI should be good at timing commodities downturns before that and less so afterwards.

Figure 6: Optimal ex-post GSCI_TR allocation using nonlinear frictions



The second logical step to test the efficiency of our proposed indicator would be to conduct an out of sample ex-ante exploitation of it. To do so, we construct a quarterly rebalanced portfolio with a 40% commodities and 60% cash strategic allocation.

Figure 7: Out-of-sample quarterly rebalanced tactical GSCI allocation using the CH indicator



We then deviate tactically from this strategic allocation according to the WI indicator input: if the indicator goes up, we increase the allocation by 25%. If it goes down, we reduce it by half and if the indicator is at zero, we go back to the 40% strategic allocation. The resulting tactical allocation is plotted in Figure 7 (*light blue continuous line*). We benchmark it against the 40%-60% commodities-cash allocation (*gray dotted line*). Since on average our tactical allocation is 60%-40% commodities-cash allocated, we also benchmark it on this alternative allocation (*dark blue dashed line*) to control for the extra commodity weight given in our tactical allocation. The results from these simulated portfolios are shown in Table 4.

Table 4: Quarterly rebalanced out-of-sample tactical evaluation vs. constant weight benchmark portfolio

	1970-2010			1970-1990			1990-2010			2000-2010		
Ptf.	**Alt.**	**C60%**	**C40%**	**Alt.**	**C60%**	**C40%**	**Alt.**	**C60%**	**C40%**	**Alt.**	**C60%**	**C40%**
Mean	2.64%	2.24%	1.96%	3.69%	3.19%	2.78%	1.72%	1.40%	1.24%	1.75%	1.42%	1.17%
Std.	(7.50%)	(6.30%)	(4.23%)	(5.35%)	(5.23%)	(3.49%)	(8.89%)	(7.04%)	(4.69%)	(10.57%)	(8.04%)	(5.33%)
IR		0.129	0.169		0.168	0.299		0.100	0.102		0.080	0.100

Whichever time period is considered, the tactically allocated portfolio consistently beats both benchmarks. The spread in performance as measured by the IR between our tactical allocation and its benchmarks is also greater for the 40% commodity allocation than it is for the 60% commodity allocation. The difference is especially large during the 1970-1990 timespan (78% larger) and small in the 2000-2010 period (25% larger) compared with an average of 31% on the entire sample.

Those out of sample simulation results seem to once again uphold our tactical pass-through allocation hypothesis in the sense that our alternative portfolio performs better when the pass-through is larger and less so when it is not. It is worth noting that in this last timing exercise, we did not account for trading costs which would inevitably drag down the performance of a tactical allocation compared to a strategic allocation which requires less frequent therefore less costly portfolio rebalancing. The outcome would most probably still be positive in the high pass-through period but the tactical allocation could backfire in the more recent period considering the relatively low IR. If the WI indicator does seem to add tactical value to a commodity strategy, it should nonetheless be used in conjunction with a battery of other indicators and not on a standalone basis to achieve the best possible allocation.

3.3. *Arbitraging core linked securities*

Lastly, the changing US macroeconomic landscape should push many long-term liability driven investors towards a swap of references from headline to core inflation as

(Fulli-Lemaire & Palidda, 2012) expose. As can be seen in Table 5, for medium to long horizon investors who can benefit from natural time averaging processes, the difference between indexing on a headline or on a core index is completely insignificant as the average spread stands at around 10 bp per annum. Meanwhile, swapping the HI reference for the CI would yield a 19% reduction in benchmark volatility over the entire period. If we focus more particularly on the last decade, we can achieve a 58% reduction.

Table 5: CI vs. HI risk reduction

Timeframe	Δ(HI,CI)		Volatility		Volatility Reduction
	Mean	Std.	HI	CI	
1970-2010	0.02%	2.15%	3.40%	2.75%	-19.15%
1970-1990	0.01%	1.86%	3.22%	2.78%	-13.49%
1990-2010	0.03%	2.39%	2.91%	1.70%	-41.82%
2000-2010	0.10%	3.15%	3.79%	1.58%	-58.25%

As we mentioned earlier on, the drive to move liability indexation towards core inflation is currently curtailed by the lack of investable core-linked assets and therefore a lack of a market reference to enable marking-to-market of such Liability Driven Investments (LDIs). The strong potential demand for such securities drove *Deutsche Bank* to launch the first investable core proxy in September 2012 (Li & Zeng, 2012) in the form of a long-short linkers-energy commodities index which serves as a reference for trading fixed-for-float "core-proxy" inflation swaps. It is thus most probable that we will see CI-linked securities issued in the near future if the derivative market for core inflation takes off, as it did for HI-linked securities decades before. The relative cheapness of issuing CI linked securities could in particular attract cash-strapped sovereign issuers eager to attract new investors and reduce their financing cost volatility arising from the HI-link.

To compensate for the lack of an investable CI security, investors wishing to hedge core inflation could either invest in a nominal bond portfolio and buy a fixed-for-float core swap overlay as in (Li & Zeng, 2012) or invest in a linkers portfolio and swap the HI for CI as in (Fulli-Lemaire & Palidda, 2012). Using our correlation analysis findings, we could hope to arbitrage those derivatives by building a replicating commodity portfolio. It is a complex problem as pricing such an instrument would require a mark-to-model approach to price the CI leg using an incomplete market cross-hedging framework.

Conclusion

The dramatic macroeconomic shift we have witnessed over the last decade has gradually reshaped our understanding of the relationship between macroeconomic variables and changes in commodity prices. The academic community has in particular delved into the disappearing pass-through of commodity price shocks into core inflation, and the far reaching consequences it has in terms of monetary policy conduct, especially so when it comes to dealing with surging crude oil prices and headline inflation. While macroeconomists and econometricians unraveled the breakdown in the pass-through, little concern was given about its consequences in terms of the allocation of commodities into inflation hedging portfolio management. This article endeavored to provide a first tentative answer to this question. The main take away from this paper can be summed-up in three arguments:

Firstly, we have established that in terms of asset pricing and as a consequence of the disappearance of the pass-through, relative variations in the core inflation index to the headline inflation index have been strongly cointegrated with financial commodity prices since the early 2000s. It opens the way for a natural commodity allocation in a core driven global macro strategy.

Secondly, we have shown in a back testing simulation exercise that as a consequence of the strong correlation between commodities and the spread between headline and core inflation, we can use forecasted core inflation data to determine an efficient strategic commodity allocation for an inflation hedged portfolio.

Thirdly, we concluded that since core inflation is on average only marginally different from headline inflation for medium to long term investors, but experienced significantly lower inflation in the last decade, we probably will experience in the near future the development of a core linked securities market. All the more so since the issuance of the first core-proxy linked derivative this year. This would pave the way for an arbitrage strategy involving core versus headline inflation swaps and a cross-replicating commodity portfolio.

The principal issues this paper has either failed to resolve or ignored are the following:

Firstly, we have showed that timing the pass-through cycle does not seem to yield an efficient tactical commodity allocation in the current macroeconomic environment. By comparison, we were able to test that in the past, with an effective pass-through operating, the indicator we constructed displayed an ability to correctly generate a significant alpha by efficiently driving the commodity allocation to match the dynamic of commodities with respect to inflation.

Secondly and lastly, we must mention that as a caveat to this study, the various backtesting exercises we ran were significantly positively impacted by what is probably an exceptional coincidence of secularly decreasing inflation and inflation risk premium with a historic bull run for commodities. One might wonder if the "*brave new world*" we were ushered into thanks to unconventional monetary policies, rapidly growing emerging countries and *peak-oil* will long leave the macroeconomic status quo untouched with a muted pass-through.

References

Amenc, N., Martellini, L., & Ziemann, V. (2009). Inflation-Hedging Properties of Real Assets and Implications for Asset–Liability Management. *Journal of Portfolio Mangement*, Summer 2009, Vol. 35, No. 4: pp. 94-110.

Amihud, Y., & Mendelson, H. (1986, December). Asset pricing and the bid-ask spread. *Journal of Financial Economics, 17*(2), 223-249.

Andrews, D. (1993). Tests for parameter instability and structural change with unknown. *Econometrica*, 821-856.

Attié, A. P., & Roache, S. K. (2009, April). Inflation Hedging for Long-Term Investors. *IMF Working Paper*.

Blanchard, O. J., & Gali, J. (2007, September). The Macroeconomic Effects of Oil Shocks: Why are the 2000s So Different from the 1970s? *NBER Working Paper*(13368).

Blanchard, O. J., & Riggi, M. (2009, October). Why are the 2000s so different from the 1970s? A structural interpretation of changes in the macroeconomic effects of oil prices. *NBER Working Paper*(15467).

Bodie, Z. (1983, Spring). Commodity futures as a hedge against inflation. *The Journal of Portfolio Management*, pp. Vol. 9, No. 3: pp. 12-17.

Bodie, Z., & Rosansky, V. I. (1980, May/June). Futures., Risk and Return in Commodity. *Financial Analysts Journal, 36*(3), 27-39.

Boivin, J., & Giannoni, M. P. (2006, August). Has Monetary Policy Become More Effective? *Review of Economics and Statistics, 88*(3), 445-462.

Brière, M., & Signori, O. (2010). Inflation-hedging portfolios in Different Regimes. *Working Paper*.

Campbell, J., & Viceira, L. (2002). *Strategic Asset Allocation: Portfolio Choice for Long Term Investors.* Oxford: Oxford University Press.

Card, D., & Hyslop, D. (1997). Does Inflation "Grease the Wheels of the Labor Market"? In C. D. Romer, & D. H. Romer, *Reducing inflation: Motivation and Strategy* (pp. 71-122). Chicago: NBER.

Chen, S.-S. (2009, January). Oil price pass-through into inflation. *Energy Economics, 31*(1), 126-133.

Chong, J., & Miffre, J. (2010, Winter). Conditional Correlation and Volatility in Commodity Futures and Traditional Asset Markets. *Journal of Alternative Investments, 12*(3), 61-75.

Conover, C. M., Jensen, G. R., Johnson, R. R., & Mercer, J. M. (2009, Spring). Can Precious Metals Make Your Portfolio Shine? *Journal of Investing, 18*(1), 75-86.

Conover, M. C., Jensen, G. R., Johnson, R. R., & Mercer, J. M. (2010, Fall). Is Now the Time to Add Commodities to Your Portfolio? *The Journal of Investing, 19*(3), 10-19.

Daskalaki, C., & Skiadopoulos, G. (2011, October). Should investors include commodities in their portfolios after all? New evidence. *Journal of Banking & Finance, 35*(10), 2606-2626.

De Gregorio, J., Landerretche, O., & Neilson, C. (2007, Spring). Another Pass-Through Bites the Dust? Oil Prices and Inflation. *Economia, 7*(2), 155-196.

Erb, C. B., & Harvey, C. R. (2006, Mar/Apr). The Strategic and Tactical Value of Commodity Futures. *Financial Analysts Journal, 62*(2), 69-97.

Fuertes, A.-M., Miffre, J., & Rallis, G. (2010, Oct). Tactical allocation in commodity futures markets: Combining momentum and term structure signals. *Journal of Banking & Finance, 34*(10), 2530-2548.

Fulli-Lemaire, N., & Palidda, E. (2012, August). *Swapping Headline for Core Inflation: An Asset Liability Management Approach.* Retrieved from SSRN: http://ssrn.com/abstract=2125962

Granger, C., & Newbold, P. (1974). Spurious regressions in econometrics. *Journal of Econometrics*, 111-120.

Greer, R. J. (1978, Summer). Conservative commodities: A key inflation hedge. *Journal of Portfolio Management, 78*(4), 26-79.

Hamilton, J. D. (1983, April). Oil and the Macroeconomy since World War II. *Journal of Political Economy, 91*(2), 228-248.

Hamilton, J. D. (2011, February). Historical Oil Shocks. *NBER Working Paper*(16790), 1-52.

Hoevenaars, R. P., Molenaarb, R. D., Schotman, P. C., & Steenkamp, T. B. (2008, September). Strategic asset allocation with liabilities: Beyond stocks and bonds. *Journal of Economic Dynamics and Control, 32*(9), 2939-2970.

Hooker, M. A. (1999). Oil and the Macroeconomy Revisited. *Working Papers -- U.S. Federal Reserve Board's Finance & Economic Discussion Series*, 1-24.

Jensen, G. R., Johnson, R. R., & Mercer, J. M. (2002, Summer). Tactical Asset Allocation and Commodity Futures. *Journal of Portfolio Management, 28*(4), 100-111.

Johansen. (1988). Statistical Analysis of Co-integration vectors. *Journal of Economic Dynamics and Control, 12*, 231-254.

Li, A., & Zeng, S. (2012, August 6). DB Core US CPI Index. (D. Bank, Ed.) *DB Fixed Income Special Report*, pp. 1-8.

Mabro, R. (1987). Netback pricing and the oil price collapse of 1986. *Oxford Institute for Energy Studies Working Paper*, 1-65.

Said, & Dickey. (1984). Testing for Unit Roots in Autoregressive Moving Average Models of Unknown Order. *Biometrika, 71*, 599-607.

Todd, E. ,., & Stephen, J. ,. (2010, October). Time Variation in the Inflation Passthrough. *Journal of Money, Credit and Banking, 42*(7).

van den Noord, P., & André, C. (2007). Why has Core Inflation Remained so Muted in the Face of the Oil Shock. *OECD Papers, 7*(4), 1-34.

Vayanos, D. (1998, Spring). Transaction Costs and Asset Prices: A Dynamic Equilibrium Model. *The Review of Financial Studies, 11*(1), 1-58.

Wing, I. S. (2008, January). Explaining the declining energy intensity of the U.S. economy. *Resource and Energy Economics, 30*(1), 21-49.

List of Figures

List of Tables